NASA's
Evolved Expendable Launch Vehicle Secondary Payload Adapter
(ESPA)
Rideshare Users Guide, and Do-no-harm Requirements Document
for
2019 Astrophysics Small Explorer and Missions of Opportunity Call
(2019 Astro ESPA RUG)

Color coding: **red/bold = requirement**, *blue/italic = guideline for maximum flight opportunity*

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1 Introduction

1.1 Purpose

This document defines requirements and guidelines for a Rideshare Payload (RPL) for proposals submitted to the Astrophysics 2019 Small Explorers and Missions of Opportunity that utilize an Evolved Expendable Launch Vehicle Secondary Payload Adapter (ESPA) or ESPA Grande.

This document was developed by NASA Science Mission Directorate (SMD) Astrophysics Division (APD).

1.2 Scope

This document provides ground rules and assumptions for RPLs intended to launch on an ESPA or ESPA Grande. **These cannot be exhaustive.** Since the primary payload and the launch vehicle will not be known at the time of proposal, and neither the ESPA ring nor the ESPA integrator will be known, specific interface requirements and generic environment definitions will not be formalized until the launch vehicle contractor and primary observatory have been selected and the mission integration cycle has begun. **It is critical that secondary payloads carry additional margins** to account for any associated applicable uncertainty.

"*Should*" statements and *Guidelines for Maximum Flight Opportunity* are given to assist proposers looking to maximize their opportunity for rideshare. Violating these guidelines does not make a payload ineligible for inclusion as a rideshare, but may limit the number of missions that are compatible with the payload's launch requirements, and may increase integration and launch costs. "**Shall**" statements refer to requirements.

This document also includes Rideshare Mission Assurance (RMA)/Do No Harm (DNH) process guidelines that focus on ensuring safety of flight for the primary mission and other rideshare payloads.

An Accommodation Study will be conducted as part of the selection process. To aid in this process, proposers are asked to document additional RPL requirements that must be accommodated using the mission-specific or mission unique hardware processes, or services as specified by the Launch Vehicle to Payload Interface Control Document.

NOTE: For this document, the ESPA and the ESPA Integrator contractor are considered part of the Launch Vehicle (LV)/Launch Vehicle Contractor (LVC) and/or Government.

1.3 Definitions and Acronyms:

1.3.1 Acronyms:

- APD – Astrophysics Division
- CCAMs – Contamination Control Avoidance Maneuvers
- DNH – Do No Harm
- DOT – Department of Transportation
- EMI – Electromagnetic Interference

- ESPA – Evolved Expendable Launch Vehicle Secondary Payload Adapter
- FEM – Finite Element Model
- GSE – Ground Support Equipment
- ICD – Interface Control Document
- IFD – In Flight Disconnect
- I&T – Integration and Test
- IPS – Integrated Payload Stack – Fully integrated ESPA with mated RPL
- LSP – Launch Service Provider
- LV – Launch Vehicle
- LVC – Launch Vehicle Contractor
- PGAA – Performance and Guidance Accuracy Analysis
- PSWG – Payload Safety Working Group
- RF – Radio Frequency
- RPL – Rideshare Payload(s)
- RMA – Rideshare Mission Assurance
- RUG – Rideshare Users Guide
- SMD – Science Mission Directorate
- TBD – To Be Determined
- TBR – To Be Resolved
- TBS – To Be Supplied
- VLC – Verification Loads Cycle

1.3.2 Definitions:

- Rideshare Payloads (RPL) are those payloads that will have no authority to impact mission integration cycle for the primary mission. This includes, but is not limited to, go-no-go call for launch, and driving environmental conditions within the fairing.

2 Documents

2.1 Applicable Documents:

- AFSPCMAN-91-710 Range Safety User Requirements Manual Volume 3 – Launch Vehicle, Payloads, and Ground Support Systems Requirements
- NPR 8715.6 NASA Procedural Requirements for Limiting Orbital Debris
- NPR 8715.7 Expendable Launch Vehicle (ELV) Payload Safety Program
- NASA-STD-6016 Standard Materials and Processes Requirements for Spacecraft
- 2018-09-18-IMAP-ESPA-SIS Specific Evolved Expendable Launch Vehicle Secondary Payload Adapter System Interface Specifications For Heliophysics Missions of Opportunity

2.2 Reference Documents

• EELV RUG	Evolved Expendable Launch Vehicle Rideshare User's Guide (SMC/LE), 2016
• TOR-2016-02946	Rideshare Mission Assurance and the Do No Harm Process – Aerospace Report (available to government only)
• GSFC-STD-7000	General Environmental Verification Standard (GEVS) for GSFC Flight Program and Projects
• MMPDS	Metallic Materials Properties Development and Standardization
• MIL-HDBK-5	Military Handbook 5, Metallic Materials and Elements for Aerospace Vehicle Structures
• EELV SIS	Evolved Expendable Launch Vehicle Standard Interface Specification, 2011 (not cleared for public circulation)
• LSP-REQ-317.01B	Launch Services Program (LSP) Program Level Dispenser and CubeSat Requirements Document
• MIL-STD-1540C	Military Standard Test Requirements for Launch, Upper-Stage, and Space Vehicles
• NASA-STD-8719.24	NASA Expendable Launch Vehicle Payload Safety Requirements

3 Ground Rules and Assumption

3.1 The Government and/or LVC will do or provide the following:

3.1.1 In a case where a RPL is not able to meet the required mass properties or milestone schedule, or is determined by NASA to be unfit to launch, then NASA has the right to replace the RPL with an equivalent mass simulator or with a backup RPL if available. Note, mass simulators will be hard mounted to the ESPA Port (non-separating).

3.1.2 LVC will coordinate RPL deployment time and sequencing with all invested stakeholders.

3.1.3 LVC will perform a separation analysis to validate no contact between RPLs, upper stage and primary payload and demonstrate no impediment to the upper stage Contamination Control Avoidance Maneuvers (CCAMs) until RPLs activate propulsion systems (if any).

3.1.4 LVC will provide Orbital Parameter Message when RPL deployment signal is sent from the LV.

3.1.5 LVC will provide the RPL separation signal (primary and redundant) to each RPL or to an ESPA sequencer.

3.1.6 LVC may provide confirmation of RPL separation/deployment over interleaved telemetry.

3.1.7 Any requirement for RPL GN2 purge systems from RPL arrival at integration facility through launch must be noted on the Accommodations Worksheet. *Max flight opportunity: no purge requirement.*

3.1.8 NASA will provide the separation system as GFE for each ESPA class RPL per section 5.2.3.

3.1.9 NASA will provide In Flight Disconnect (IFD) as GFE to each ESPA class RPL per section 5.3.2.

3.1.10 Facility space will be provided at the ESPA Integrator. It can be used by RPLs for receiving, unpacking, functional checks, battery charging, and facility power. *Any requirements to use this space for fueling or pressurization of a propulsion system must be specified on the Accommodation Worksheet.*

3.1.11 ESPA Integrator and LV integration facility's temperature and humidity will typically be controlled to the following levels:

Temperature: 60° – 80° Fahrenheit (15.6° - 26.7°Celsius)

Relative humidity: < 65%

3.1.12 Clean room environment will be provided for integrated contamination control environments to meet contamination requirement for primary mission.

3.2 RPLs will not have the authority to make a GO, No-GO call on day of launch.

3.3 RPLs will have no authority to change launch readiness date of Primary mission.

3.4 RPLs **shall** meet Primary Mission Integration Cycle (e.g., PGAA-1, 2, 3, and Verification Load Cycle (VLC)). See Appendix A of the 2018-09-18-IMAP-ESPA-SIS for an example ESPA rideshare integration.

3.5 At a minimum, the RPL **will be required** to provide the following data products to meet the Primary Mission Integration Cycle.

- Computer-Aided Design (CAD) Model
- Finite Element Model (FEM)
- Thermal Math Model (TMM)
- Venting Model
- Official Mass Properties Data
- Safety Data Package
- Test Procedures and Test Reports
- Separation Systems Characteristics (unless provided as GFE)
- Slosh Model (if applicable)

3.6 The RPL team **must** be prepared to supply a flight-qualified mass simulator to replace their payload, as a schedule risk mitigation for the primary mission.

3.7 RPLs **must** support and comply with the primary mission Payload Safety Working Group (PSWG).

3.8 RPL will have no physical access post fairing encapsulation; this includes launch delays/scrubs. *Any requirements for access to the RPL after delivery for integration must be noted on the Accommodation Worksheet. Max flight opportunity: no requirement for late access to RPL.*

3.9 *Any requirement for down range telemetry support for RPL deployments must be noted on the Accommodation Worksheet. Max flight opportunity: no requirement for down range telemetry for RPL deployment.*

3.10 RPLs must meet Department of Transportation requirements and acquire applicable certification for the transportation of hazardous commodities and/or pressurized system when not at the launch site.

3.11 **All RPLs should anticipate that they will likely be deployed after the Primary mission deployment (to be refined).**

3.12 *For maximum flight opportunity, proposers should assume that the launch vehicle upper stage will act as a 3-axis-stabilized inertial platform. Any requirement for the launch vehicle to be pointed in a particular direction at the moment an RPL is released should be noted on the Accommodation Worksheet.*

3.13 RPLs should anticipate that they will be required to remain “dormant” (with no RF transmission and no appendages deployed) for some period following their release.

4 Rideshare Mission Assurance and Do-No-Harm

As Rideshare missions become more feasible and accepted in today’s space and science industry, there is a growing need to mitigate risks from the RPLs to the primary mission and all payloads on the mission. The Department of Defense (DoD)

Space Test Program (STP) has implemented a hybrid system of risk mitigation called Rideshare Mission Assurance (RMA). The objective of the RMA process is to provide all mission partners with a degree of certainty that all payloads included on a mission will do no harm (DNH) to each other, or to any operational aspect of the launch. The DoD STP developed a Rideshare Mission Assurance Do-No-Harm (TOR-2016-02946) guideline document. This document is only releasable to Government and Government contractors and will not be in the program library; the relevant requirements are included in this document.

The RMA process mitigates risks by assessing each payload flying on a mission against a tailored set of criteria, known as "Do No Harm" criteria. The primary concern of the RMA process is to ensure that the payloads are robust enough to survive the environments experienced during launch and/or will not inadvertently power on, and perform functions that could be harmful. Other areas also assessed includes any co-use of facilities during the launch campaign and the critical function inhibit scheme utilized by the payload. The focus of this process is to ensure safety of flight for all mission partners and is <u>not to ensure mission success for individual RPLs</u>. <u>It is the responsibility of the RPLs to ensure their own mission success.</u>

This document incorporates key elements of the DoD RMA process for this early procurement and concept development phase. Once the LVC is on contract, this process will be formalized and a detailed mission specific set of Do-No-Harm criteria will be developed and validated as part of the overall mission integration cycle.

Payloads shall comply with provisions of NPR 8715.7 Expendable Launch Vehicle (ELV) Payload Safety Program.

5 Requirements:

5.1 Mission Trajectory

5.1.1 The RPL orbit insertion shall be designed not to make physical contact with the primary spacecraft, or LV performing end of mission operations. Its target, including C3, will be dependent on excess capability of the launch vehicle after inserting the primary spacecraft.

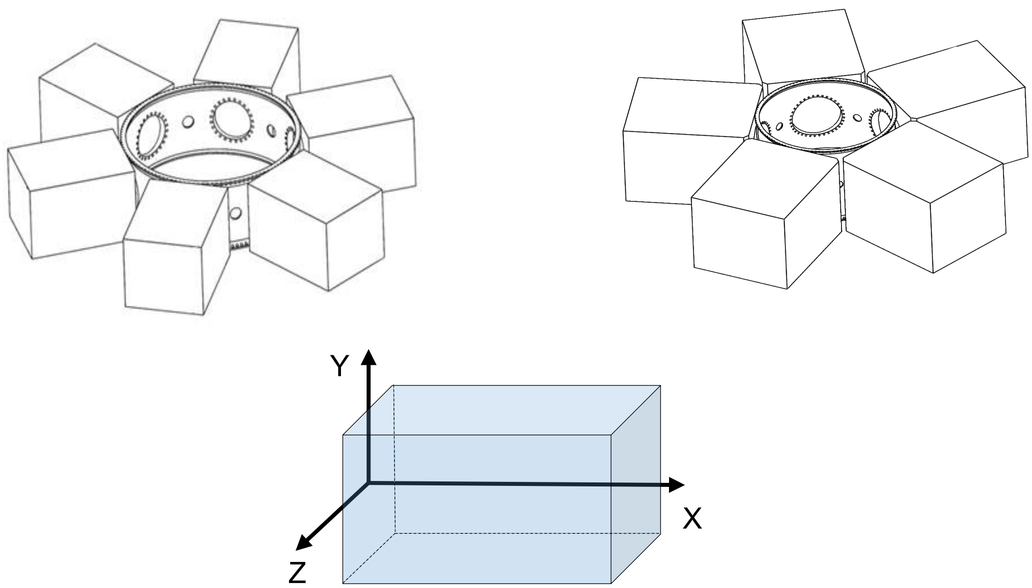
5.1.2 RPLs consisting of CubeSat constellations (or that otherwise separate into multiple free-flying components) shall provide analysis showing no re-contact.

5.2 Mechanical

5.2.1 Reference Coordinates and Origin

5.2.1.1 RPL will use the coordinate system specified in Figure 5.2. The coordinate origin is that the center of the -X face of the spacecraft (the center of the ESPA port). The X-dimension is measured from the ESPA port interface plane, and the dimension in the table includes the width of the separation system.

Figure 5.2 ESPA, ESPA Grande and RPL Coordinate System



5.2.2 ESPA Class Payloads Interface Requirements

5.2.2.1 RPLs *should not* exceed the mass and volume requirements as specified in Table 5.2; *RPL with lower mass will be easier to accommodate*.

Table 5.2 ESPA RPL Mass, Volume Interface Requirements for 4-meter Fairing

ESPA	Max RPL Mass[(4)]	Allowable RPL Volume	RPL Interface
ESPA Grande 5 Port	450 kg	42”x46”x38” [(1, 2, 3)] Y, Z, X	24” circular
ESPA 6 Port	220 kg	24”x28”x38” Y,Z,X	15” circular

(1) X-dimension assumes a 4-meter fairing; ESPA Grande on 5-meter fairing allows 56”.
(2) The Atlas V 4-meter fairing has additional fairing sweep stay-out zones at the base of the fairing that may be applicable. These are defined in the

LV users guide at: https://www.ulalaunch.com/docs/default-source/rockets/atlasvusersguide2010.pdf

(3) The RPL X-axis dimension includes the separation system width. This means separation system width will be subtracted from the 38” allowable dimension.

(4) The flyaway portion of the separation system shall be considered as part of the RPL total mass.

5.2.2.2 RPLs *should* maintain a center of gravity as follows:

- CG along the RPL X-axis *should* be less than 20” from the ESPA interface port
- Lateral CG (Y, and Z axis) *should* be within 1” of the RPL X-axis centerline

5.2.2.3 Deleted

5.2.3 ESPA Class Separation Systems:

5.2.3.1 NASA will provide the Separation System as GFE: this will be the RUAG PAS 381S (15”) for ESPA, and the RUAG PAS 610S (24”) for ESPA Grande. Specification for this separation system are listed below. Use of this system is **required**.

RUAG PAS 381S (15”): https://www.ruag.com/sites/default/files/media_document/2018-06/PAS%20381S%20Separation%20System_rev4.pdf

RUAG PAS 610S (24”): https://www.ruag.com/sites/default/files/media_document/2019-03/PAS%20610S%20Separation%20System.pdf

5.2.4 Static Loads

5.2.4.1 The peak line load across the ESPA/RPL interface *should not* exceed 400 lbs. /in. This is defined at the separation plane between the active and passive parts of the separation system. This limit is based on a maximum LV acceleration of 8.5g; if the LV acceleration is greater, this load may be restricted to lower values.

5.2.5 RPL Stiffness

5.2.5.1 Max flight opportunity: RPLs *should* have first fixed-free fundamental frequencies above 75 Hz constrained at the separation system interface plane.

5.3 Electrical Requirements

5.3.1 Electrical Power

5.3.1.1 RPLs **shall** be powered off during all integrated and hazardous operations and from T-5 minutes through deployment. Once the RPL has been integrated to the ESPA, the RPL can only be powered on for battery charging and hazardous system monitoring. *Requirements for powering on after integration to the ESPA must be detailed in the accommodation worksheet.*

5.3.1.2 The RPL T-0 electrical interface **shall** be deadfaced (electrically isolated) at T-5 minutes prior to launch.

5.3.1.3 RPLs **shall** incorporate a Remove Before Flight pin that cuts power to the spacecraft bus. This will be used during transportation and ground processing/integration activities.

5.3.2 Connectors:

5.3.2.1 LVC will provide one 12-pin or 15-pin in flight disconnect (IFD) connector and one spare to each of the RPL developers for incorporation into spacecraft build. Use of this system is **required**.

5.3.3 Battery:

Battery charging can be provided through an ESPA T-0 connector. *Requirements for battery charging and monitoring must be detailed in the Accommodation Worksheet.* Battery charging will not be provided during integrated operation or hazardous operations. LVC will provide RPL telemetry for battery monitoring data up until T-5 minutes before launch.

5.3.3.1 RPLs **shall** utilize Underwriter Laboratory (or-equivalent) approved batteries with no modifications and be compliant with Range Safety requirements (AFSPCMAN-91-710).

5.3.3.2 RPLs **shall** incorporate battery circuit protection for charging/discharging to avoid unbalanced cell condition.

5.3.3.3 RPLs **shall** meet battery charge monitoring requirements per AFPSCMAN-91-710. RPL monitoring of the charge activity **will be required** to avoid generation of Radio Frequency (RF) emissions that may affect nearby hardware.

5.4 Environments:

This section contains general requirements for early development/design which would be adequate for the launch vehicles currently on contract, but may change when new launch vehicles become available. Mission specific environments will be defined once the launch vehicle contractor and primary observatory have been selected and the mission integration cycle has begun. These Mission specific environments will be flowed down to the RPLs from the Launch Vehicle to Primary Payload Interface Control Document (ICD). The environments defined in the LV to Primary Payload ICD will take precedence over the requirement defined in this section.

5.4.1 Thermal

5.4.1.1 RPLs *should not* impose specific requirements that constrain the environment of the launch vehicle, or specify temperature and humidity requirements beyond what is given in 3.1.11 for the integration facility.

5.4.2 Random Vibration

5.4.2.1 RPLs *should* be designed to the representative composite random vibration environments defined in Appendix B of the 2018-09-18-IMAP-ESPA-SIS.

5.4.3 Sine Vibration

5.4.3.1 RPLs *should* be designed to the representative composite sine vibration environments defined in Appendix B of the 2018-09-18-IMAP-ESPA-SIS.

5.4.4 Acoustics

5.4.4.1 RPLs *should* be designed to the representative composite acoustic environments defined in Appendix B of the 2018-09-18-IMAP-ESPA-SIS.

5.4.5 Shock

5.4.5.1 RPLs *should* be designed to the representative composite acoustic environments defined in Appendix B of the 2018-09-18-IMAP-ESPA-SIS.

5.4.6 Contamination

The primary mission will drive these requirements, and they may be more restrictive than what is listed below.
RPL *should* adhere to ISO Level 8 (Class 100,000) cleanliness requirements and *should* require no greater than this cleanliness level.

5.4.6.1 RPLs *should* be cleaned, certified and maintained to level 500A per IEST-STD-CC1246.

5.4.6.2 RPLs *should* undergo thermal vacuum bakeout per ASTM E2900.

5.4.6.3 RPLs material selection **shall** be in accordance with NASA-STD-6016 Standard Materials and Processes Requirements for Spacecraft.

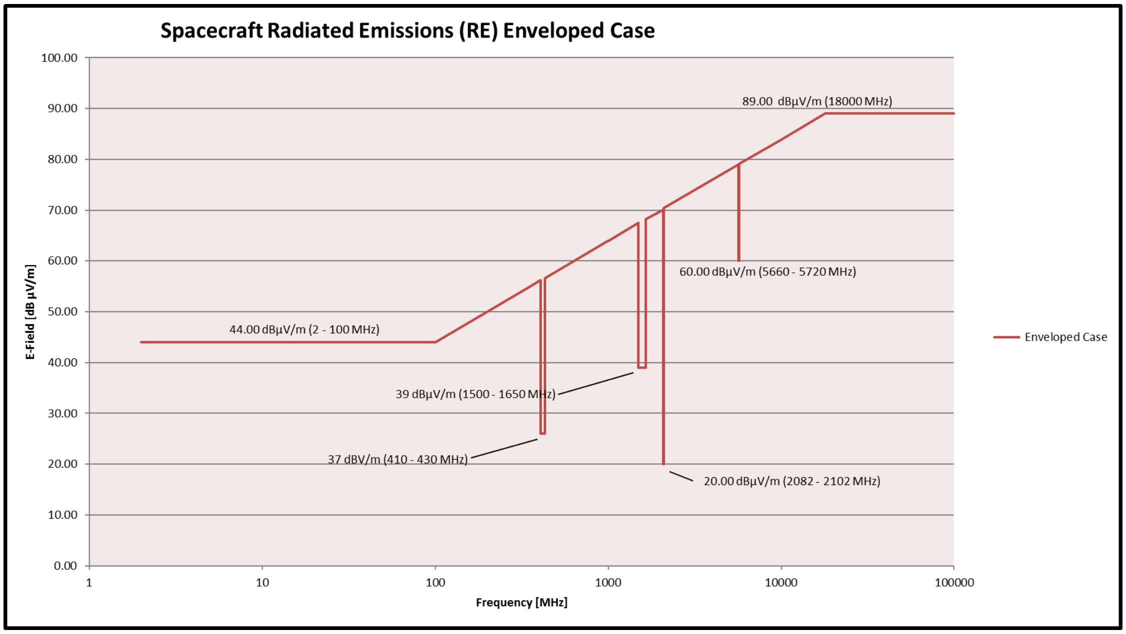
5.4.7 Electromagnetic Interference/Electromagnetic Compatibility (EMI/EMC)

5.4.7.1 RPLs *should* not conduct free radiation during launch processing. “Plugs out” testing may be conducted with antenna hats.

5.4.7.2 RPLs *should* ensure Underwriter Laboratory (UL) or equivalent certification on all electrical ground support equipment (EGSE).

5.4.7.3 The RPLs radiated emissions at the payload interface plane *should* not exceed the levels shown in Figure 5.3.

Figure 5.3, Representative Constraint on Spacecraft Radiated Emissions (from 2018-09-18-IMAP-ESPA-SIS, based on requirements of the range and of then-current current launch vehicles)



5.4.7.4 The RPLs *should* be compatible with the launch vehicle and Range radiated emissions: requirements for range and current launch vehicles are shown below:

20 V/m 2 MHz to 18 GHz

5.4.7.5 The RPLs *should* meet the following EMI margin requirements:

5.4.7.5.1 Electroexplosive Devices (EED) - The RPLs *should* demonstrate a 20 dB Electro-Magnetic Interference Safety Margin (EMISM) to the RF environment (vs. dc no-fire threshold) for all EED firing circuits.

5.4.7.5.2 Safety Critical Circuits - The RPLs *should* demonstrate a 6 dB EMISM to the RF environment for all safety critical circuits and circuits that could propagate a failure to the launch vehicle.

5.4.7.6 RPLs *should* be magnetically clean from encapsulation through separation on orbit, with magnetic fields less than or equal to 1 Gauss at 1 meter from the RPL and all ground support equipment (GSE).

5.4.8 Radiation

5.4.8.1 No hazardous ionizing radiation is permitted.

5.5 Ground Operations

5.5.1 RPLs shall provide GSE lifting fixtures to support mate operations onto the ESPA.

5.5.2 RPLs shall provide their own GSE.

5.6 Requirements for CubeSats, and CubeSat Constellations

5.6.1 RPLs proposing CubeSat payloads shall provide their own flight qualified dispenser system that meets the requirement of this specification. The dispenser system will be mounted to the ESPA Port. Only the CubeSats will be deployed.

5.6.2 CubeSat RPLs shall meet the requirement of this specification, except for sections 5.2.1, 5.2.2, 5.2.3, 5.2.4, 5.2.5, and 5.3.2.

6 Safety

6.1 Fault Tolerance

6.1.1 All hazardous operations (such as deployments of deployables, RF transmission and propulsion activation) shall be dual fault tolerant.

6.2 Hazard System activation

6.2.1 RPLs will have the ability to activate hazardous systems based on time limit identified in the LV to Primary Payload mission ICD. These hazardous systems must be noted in the Accommodation Worksheet: they may consist of, but are not limited to:

- Deployments of solar arrays, booms, and antennas etc. The proposal must show that these will not be deployed inadvertently such as to impact the primary spacecraft or other secondaries.
- RF transmission. The proposal must show RF inhibit architecture such that the spacecraft cannot transmit until after it has separated and achieved a safe distance from the other spacecraft and from the upper stage.
- Propulsion system
- Any other systems

6.3 Propulsion and Pressure vessels

6.3.1 RPLs with pressure vessels shall comply with Range Safety (AFSPCMAN-91-710) standards at the launch site.

6.3.2 RPLs shall comply with Range Safety (AFSPCMAN-91-710) standards for Loading and offloading of propellants and hazardous commodities.

6.4 Hazardous Materials

6.4.1 RPLs hazardous material **shall** conform to AFSPCMAN 91-710, Range Safety User Requirements Manual Volume 3 – Launch Vehicles, Payloads, and Ground Support Systems Requirements.

6.5 Orbital Debris

6.5.1 RPLs mission design and hardware **shall** be in accordance with NPR 8715.6B NASA Procedural Requirements for Limiting Orbital Debris and Evaluating the Meteoroid and Orbital Debris Environments.